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Warkworth Geodetic Station as a Potential GGOS Core Site in New Zealand

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Abstract

We present New Zealand's recent activities and discuss plans for geodetic VLBI research. The roadmap for the Warkworth station to evolve into a GGOS core site in the Southern Hemisphere is discussed. We present the results of improving the estimation of the ocean tide loading displacement at the Warkworth site. A more accurate coastline model based on SRTM datasets was constructed. The site-dependent tidal coefficients of the 11 main tides were computed by using this new coastline model. These were compared with the standard tidal coefficients from the Ocean Tidal Loading Provider; the differences between the ocean tidal loading displacements at Warkworth calculated from both site-dependent tidal coefficients were about ±1 mm in the horizontal components and ±2 mm in the vertical component, respectively. These are large differences compared with our aim of 1 mm accuracy for baseline measurements.

1. Introduction

Figure 1. AUT's 12-m radio telescope at Warkworth (WARK12M).

The Institute for Radio Astronomy and Space Research (IRASR) of the Auckland University of Technology (AUT) operates the 12-m fast slewing radio telescope (WARK12M) located near Warkworth, 60 km north of Auckland (Figure 1) [1]. Since 2011, WARK12M has operated as a network station of the International VLBI Service for Geodesy and Astrometry (IVS). In this report, we describe IRASR's recent activities and plans for continuing geodetic VLBI research. In addition, we present the results of improvements in the estimation of ocean tide loading displacement at Warkworth.

2. Recent Activities

The New Zealand VLBI station, WARK12M, has participated in global IVS sessions, mainly R1 and R4 sessions, since the beginning of 2011. The station is connected to the rest of the world with a 1 Gb/s fiber link operated by the Kiwi Advanced Research and Education Network (KAREN). A sustained data rate of 512 Gb/s was achieved in July 2011, when the first real-time e-VLBI observations were conducted between Warkworth and the first ASKAP antenna (with the participation of the Australian East Coast radio telescopes—the Australian Long Baseline Array network). We are establishing the geodetic experimental environment for the purpose of the ultra-rapid EOP measurements on the New-Zealand–Japan baseline. Since last year, we have carried out fringe tests, correlation processing, bandwidth synthesis, and data analysis. This progress was made with assistance from the National Institute of Information and Communications Technology, Kashima Space Research Center. At the same Warkworth station, a 30-m antenna was handed over from Telecom New Zealand to AUT University at the end of 2010. It is located 200 m north of the 12-m radio telescope. After conversion of the antenna into a radio telescope (the first light is expected in the middle of 2012), the 30-m dish will be used for both astronomical and geodetic research.

3. Contribution to Geodetic Research

New Zealand is located on the plate boundary of the Pacific Plate and the Australian Plate. Figure 2 shows the geological situation of New Zealand. Dots indicate earthquakes that occurred during 2008–2010. Triangles indicate the locations of major volcanoes. The tectonic plate motion in New Zealand is approximately 4 cm/yr [2]. Uplifts and subsidence are reported in several geological surveys [3]. About 5 mm/yr uplift is observed in the Southern Alps of the South Island from GPS observations [4]. A very destructive earthquake occurred at Canterbury in February 2011 [2].

New Zealand has two continuously operating GNSS networks (Figure 3): PositioNZ and GeoNet. The PositioNZ network consists of 31 stations located across mainland New Zealand, plus two stations in the Chatham Islands and an additional three in the Ross Sea region of Antarctica. The PositioNZ network was used to construct New Zealand's geodetic system (NZGD2000). GeoNet is a network/system designed for monitoring earthquakes, volcanic unrest, land deformation, geothermal activity, and tsunamis. Each GeoNet station consists of GNSS equipment, a seismometer, an accelerometer, a tide gauge, and a sea level pressure measurement device. The GeoNet stations are mainly located in active volcanic areas of New Zealand's North Island. As New Zealand now has a VLBI capability, we are proposing development of joint research and synergy between VLBI and GPS for the benefit of the geoscience community in New Zealand [5].

The Global Geodetic Observing System (GGOS) is currently widely discussed as a major trend in global geodetic research. GGOS aims to achieve challenging goals by using and integrating advanced geodetic techniques [6]. To achieve these goals, it is important that many stations equipped with multiple co-located geodetic observation techniques participate in this project. The WARK12M station has the capability of becoming a GGOS core site in New Zealand. The location of WARK12M in the Southern Hemisphere can play an important role in making the distribution of GGOS core stations around the globe more regular.

Currently, the Warkworth station has two (GNSS and VLBI) out of the four co-located space geodetic techniques required by GGOS, as well as ground monuments for local survey. We are investigating the opportunity for installation of an absolute or superconducting gravimeter at the Warkworth station. To expand the application of the geodetic research in New Zealand, we have initiated plans to build a new VLBI station (with GNSS) in New Zealand's South Island.

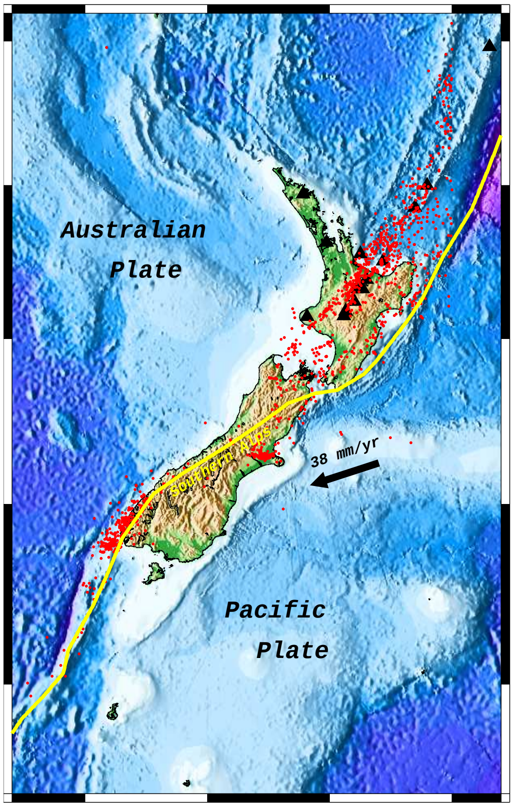

Figure 2. New Zealand's geological situation. The tectonic plate boundary is shown with curves. Dots indicate the earthquake epicenter locations ($M \geq 1$, from January 2008 to December 2010) according to the USGS/NEIC earthquake catalog. Triangles indicate locations of major volcanoes.

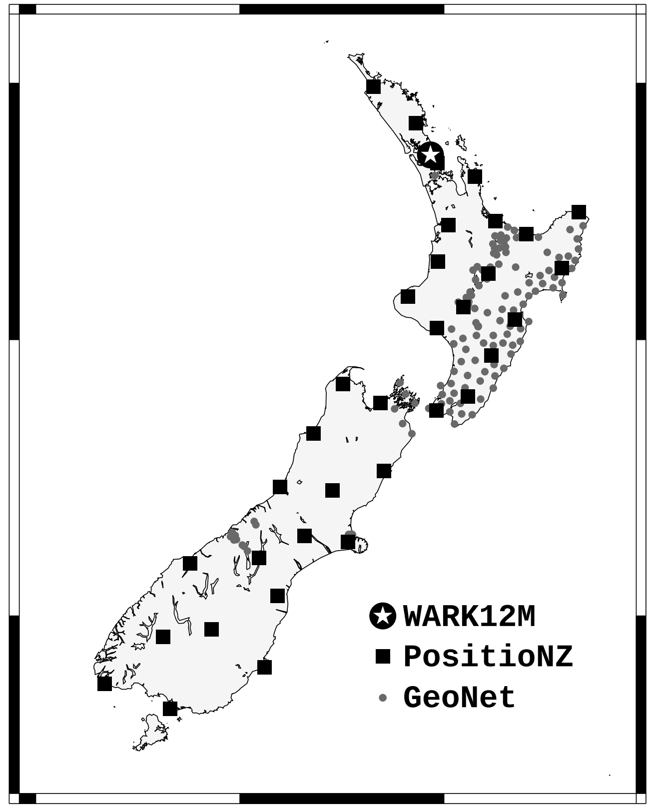

Figure 3. The location of the 12-m radio telescope (WARK12M) is shown with a star. Stations of PositioNZ and GeoNet (except those in the Chatham Islands and Antarctica) are shown with squares and dots, respectively.

4. The Ocean Tide Loading Displacement at Warkworth

The Radio Astronomical Observatory at Warkworth, New Zealand, does not have an appropriate geodynamic model to use in geodetic VLBI analysis because it is a young observatory. As the first step towards a detailed geodynamic model for the WARK12M station, we investigated the ocean tide loading effects at Warkworth.

The M2 tide propagates counterclockwise around New Zealand [7, 8]. The displacements due to the ocean tide loading calculated for Warkworth are up to ±10 mm for the horizontal components, and ±40 mm for the vertical component. To compute the ocean tide loading displacement, geodetic analysis software uses the site-dependent tidal coefficients of 11 main tides. Usually, the site-dependent tidal coefficients are obtained from the Web-based program called the Ocean Tide Loading Provider (OTLP) which is maintained by Onsala Space Observatory [9]. Basically, it works well, but it is not sufficiently accurate for our station. OTLP employs the coastline data which is taken from the GMT package [10]. Figure 4 shows the full-resolution coastline (bold curves), sea area from SRTM3 data (blue area, please see Web version), and the satellite images near Warkworth. SRTM3, one of the datasets of the Shuttle Radar Topography Mission [11], provides 3 arc-second grid data all over the world. There are obvious differences within the range of 5 km from Warkworth between the GMT and STRM3 datasets.

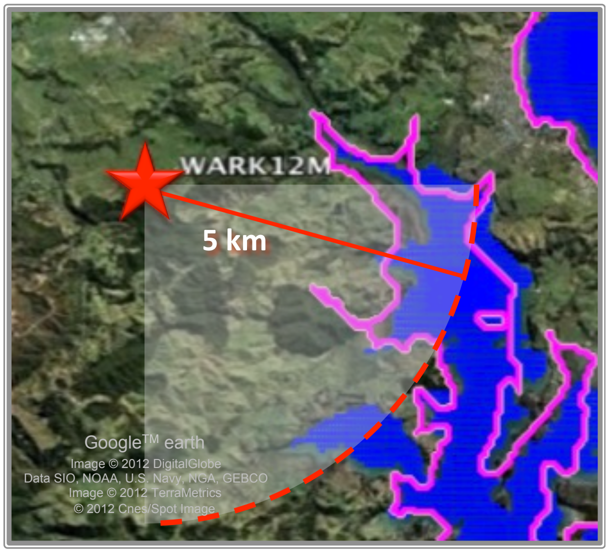

Figure 4. The GMT's full-resolution coastline (bold curves), sea area from SRTM3 data (blue area), and the satellite images of GoogleEarth near Warkworth.

We calculated the site-dependent tidal coefficients of the 11 main tides of Warkworth by using GOTIC2 software [12] with SRTM grid data. For comparison, we also obtained the tidal coefficients using the OTLP. To calculate the OTL displacement, we employed c5++ software. This software is the new space geodetic analysis software developed at NICT, Hitotsubashi University, JAXA, and AUT. Figure 5 shows the displacement of the OTL at Warkworth and the difference between the OTLP and this study. The difference in the East-West direction is less than 1 mm. The difference in the North-South direction is about ± 1 mm. Finally, the vertical difference is ± 2 mm. These differences are significant considering our aim of 1 mm accuracy and should not be ignored. We compared OTL displacement at other GPS sites in New Zealand. All sites located north of Auckland indicated a similar difference. The difference at almost all other sites was not as large as in Warkworth.

5. Conclusion

We describe IRASR's recent activities and our plans for geodetic research. IRASR's radio telescope is ready to contribute to New Zealand and global geodetic research. AUT has started discussions with related institutes in New Zealand to establish a fundamental geodetic station at Warkworth. The results of improving the estimation of the ocean tide loading displacement at Warkworth are shown. We constructed a more accurate coastline model and calculated the site-dependent tidal coefficients of the 11 main tides by using new and more accurate coastline data. We demonstrated that the difference of grid data is not small compared to a 1 mm accuracy. For the next step, we are going to apply this result to geodetic analysis and evaluate the effect.

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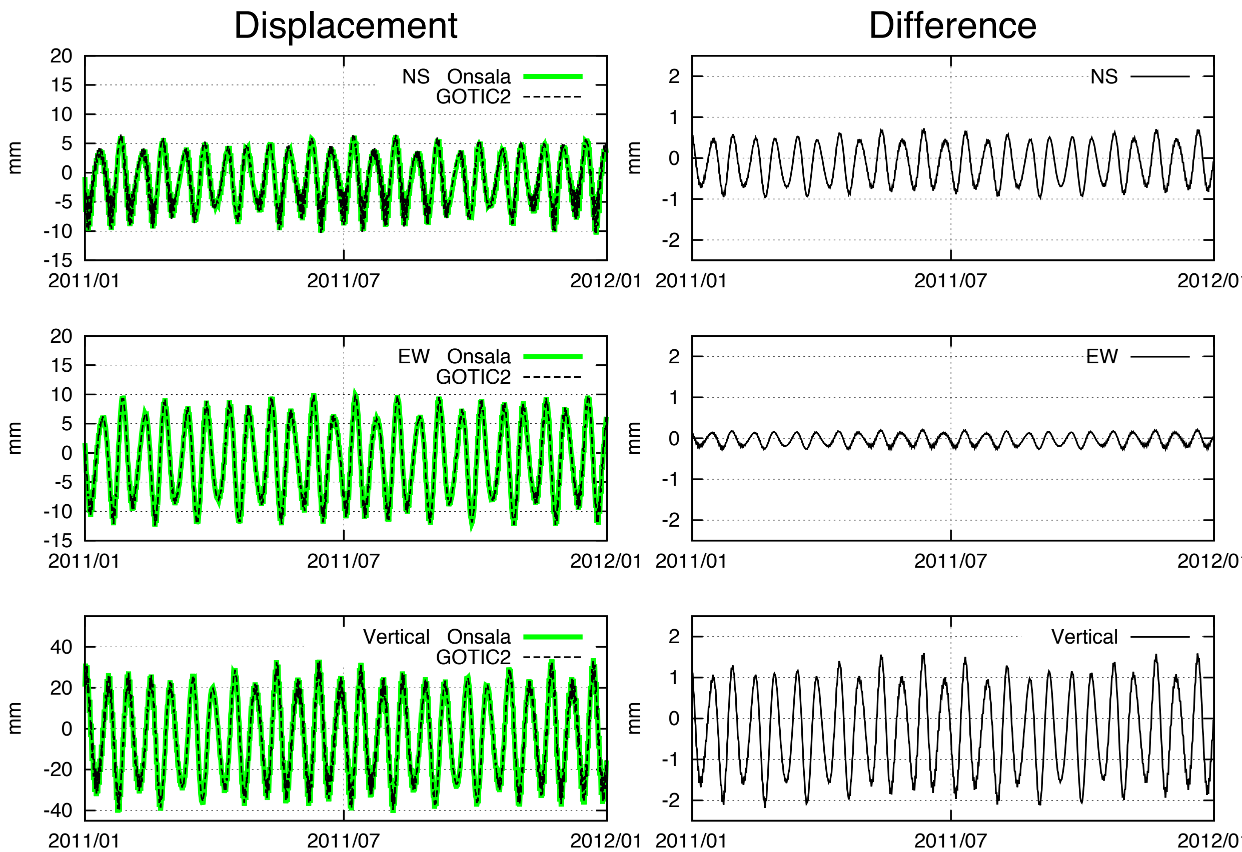

Figure 5. The ocean tidal loading displacement at Warkworth (left) and the difference in results that were calculated from two grid models (right).

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